

sides, wherein one edge of each bending element is secured to the support strip.

The Braille cell further includes a Braille dot positioned on the topside of the flexible diaphragm.

The electroactive polymer bending elements in accordance with the present invention include an electroactive polymer layer secured to a substantially rigid layer. The electroactive polymer layer may be an electronic electroactive polymer such as a poly vinylidene fluoride (PVDF) or an ionic electroactive polymer such as an ionomeric polymer metal composite (IPMC). Additional electroactive polymers known in the art are also within the scope of the present invention. To supply the voltage necessary to activate the electroactive polymer, the electroactive polymer layer further includes a plurality of photo lithographed microelectrodes. The microelectrodes are placed in alternating fashion having a common positive bus and a common negative bus. A switchable power supply is provided in circuit communication with the microelectrodes of the electroactive polymer bending element. The switchable power supply delivers a voltage to the microelectrodes sufficient to result in the bending of the electroactive polymer bending element.

In an additional embodiment, the housing is filled with a fluid. The fluid provides a pressure medium with which to deform the flexible diaphragm. Water, in addition to a variety of fluids are within the scope of the invention. The viscosity of the fluid affects the reaction time of the Braille dot.

In an embodiment of a full-page refreshable Braille display apparatus in accordance with the present invention, is provided a plurality of Braille cells, each Braille cell including a substantially fluid-tight housing, the fluid-tight housing further comprising a tactile member cover, a tactile member in the housing, the tactile member being movable between a neutral position at which the tactile member is substantially flush with the tactile member cover and is not palpable and a reading position at which the tactile member is extended beyond the tactile member cover and is palpable. A support member in the housing is included for supporting the tactile member when the member is in the reading position, and an actuator is integrally connected to the support member for moving the tactile member between a neutral position and a reading position through the displacement of fluid within the substantially fluid-tight housing. The actuator is actuated by an electrical voltage and further includes an electroactive polymer which bends upon application of an electrical voltage, the bending of the electroactive polymer displaces a fluid volume within the housing sufficient to move the tactile member between a neutral position and a reading position, the bending of the electroactive polymer is sufficient to move the support member to support the tactile member when in the reading position.

An important advantage of the present invention is that the novel Braille cell disclosed is very compact, thereby allowing the fabrication of a full-page Braille display able to demonstrate both character and graphic information.

An additional advantage of the present invention is the reduction in power requirements for the Braille cell. The combination of the electroactive polymer actuator and the stabilizer and support blocks provides a hydraulic and latching mechanism that provides an over 30 gram supporting force for the Braille dot. The power consumption is very low because the latching action of the stabilizer block and support members provides the large supporting force for the Braille dot. The power required to drive the electroactive polymer bending elements to generate the pressure to push

up the diaphragm is relatively low and the supporting force is then supplied by the support members.

Another advantage of the present invention is the realization of a less than 100 ms response time. This response time can be achieved because the response time for the electroactive polymer bending elements is in the range of milliseconds due to the characteristics of the electroactive polymer.

BRIEF DESCRIPTION OF DRAWINGS

For a fuller understanding of the invention, reference should be made to the following detailed description, taken in connection with the accompanying drawings, in which:

FIG. 1 is a diagrammatic view of the housing of the Braille cell in accordance with the present invention.

FIG. 2 is a diagrammatic view of the Braille cell in accordance with the present invention.

FIG. 3 is a diagrammatic view of the operation of the Braille cell in a palpable state in accordance with the present invention.

FIG. 4 is a diagrammatic view of the operation of the Braille cell in an impalpable state in accordance with the present invention.

FIG. 5 is a diagrammatic view of the construction of the electroactive polymer bending element in accordance with the present invention.

FIG. 6 is a diagrammatic view of the Braille cells on the present invention incorporated into a Braille display assembly.

DETAILED DESCRIPTION

In the following detailed description of the preferred embodiments, reference is made to the accompanying drawings, which form a part hereof, and within which are shown by way of illustration specific embodiments by which the invention may be practiced. It is to be understood that other embodiments may be utilized and structural changes may be made without departing from the scope of the invention.

The supporting force required for a Braille dot within a Braille display is approximately 30 grams. This supporting force is sufficient to provide the reader with a comfortable tactile feel. Concurrently, an approximately 0.7 mm displacement for the Braille dot insures that the dot will be palpable by the reader. These requirements must be met within less than an approximately 100 ms response.

The present invention provides a Braille cell based on electroactive polymer actuator technology, which overcomes the limitations of the piezo electric ceramic (PZT) Braille cell commonly used in the art. It is known that the strain of the PZT material is small, and therefore a long lever type bimorph is required to make an actuator using PZT technology to move the Braille dot. The long lever bimorphs required a significant amount of space. Due to the large space requirements, there is a limitation to how many PZT Braille cells can be incorporated into a Braille display. The Braille cell of the present invention overcomes the size limitations associated with PZT Braille cells.

The present invention utilizes electroactive polymer actuators. Due to the inherent characteristics of the electroactive polymer active material, a large displacement can be obtained that will move the Braille dot. Additionally, the electroactive polymer is light weight and the power consumption is very low. As such, the light, compact and